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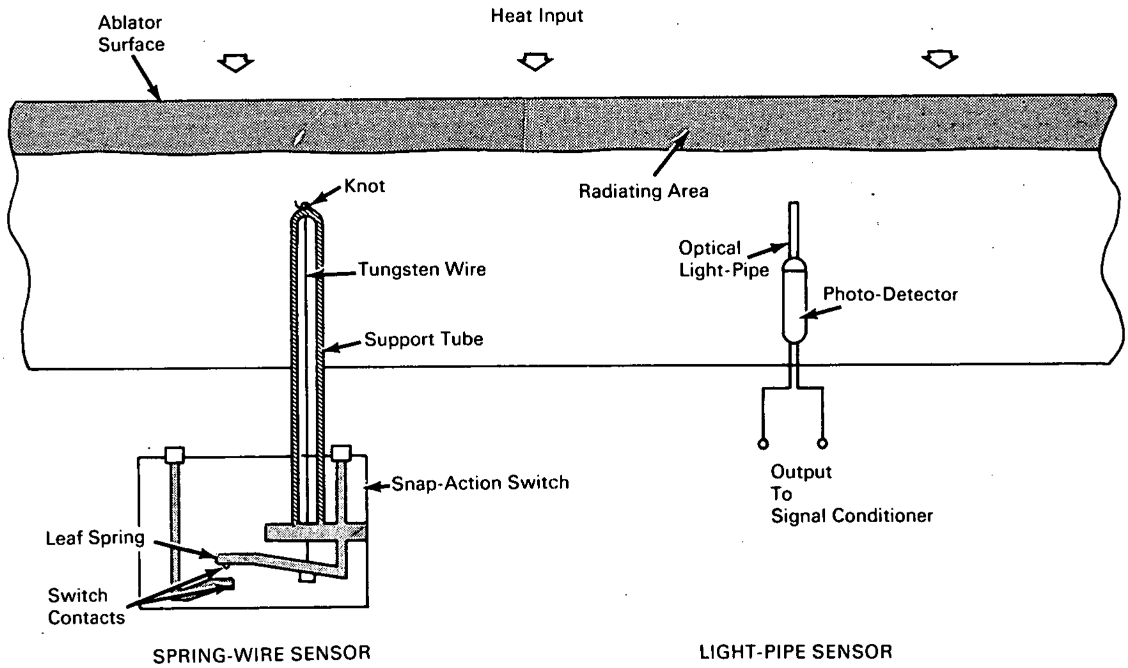
Sensors Measure Surface Ablation Rate of Reentry Vehicle Heat Shield



The problem:

The measurement during reentry of the surface erosion rate of the ablation material which provides heat protection for the spacecraft. To be effective, the technique used must meet the requirement that a minimum of foreign material be embedded in the heat shield to insure that the sensing device will not disturb the basic ablative properties of the material. Also, the instruments must be simple, highly reliable, and unaffected by the external reentry environment, particularly the ionized plasma surrounding the space vehicle.

The solution:

Placement of a number of simple event sensors at precise depths in the heat shield. Each sensor is activated when the ablator surface erodes to the location of a sensing point. Knowing the depth of each sensing point and the time of activation, ablator surface erosion rate can be determined.

How it's done:

The light-pipe sensor uses the visible radiation present at the surface of an ablating heat shield. An

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optical system consisting of a high melting point optical fiber and photodetector is embedded in the ablation material. As the ablation process advances, the heated area above the end of the optical fiber becomes incandescent and the radiated light is channeled through the fiber to the photodetector. As the ablation surface approaches the end of the fiber, the intensity of the light increases causing a proportional change in photodetector output. When the detector output reaches a predetermined level which has been experimentally selected to correlate ablator surface position with the end of the fiber, electronic switch closure circuitry is actuated.

The spring wire sensor consists of a metal tube attached to a snap-action switch. The tube is constructed of material which melts at or near the expected ablator surface temperature. A fine tungsten wire, fixed to the end of the tube, is passed through the tube and attached to the leaf spring of the switch to hold the spring in tension. The tubing is located in the ablator at the desired depth. As the material surface erodes to the location of the sensor, the very steep temperature gradient at and just beyond the ablator surface softens the tubing and releases the wire, allowing the switch to close.

Notes:

1. The light-pipe sensor in its present configuration is limited to applications in materials which are not transparent. Synthetic sapphire, .016" dia., is used to construct the optical fiber. The choice of tubing for the spring wire sensor depends on the ablator surface temperature. High melting point tubings such as tungsten–rhenium and molybdenum have been used with heat shields having high surface temperatures. For conditions where surface temperatures are lower, aluminum and stainless steel support tubes have been used successfully. The support tube diameter is .020".
2. These sensors have been used in several material evaluation flight experiments and a multitude of ground plasma-jet tests. Other tests have been conducted in rocket-exhaust facilities of the New York Atomic and Development Authority—Malta Test Station. Tests were conducted in a variety of ablators including phenolic–graphite, high and low density phenolic–nylon, teflon, silicon rubber based materials, and an epoxy novelac composite.
3. Additional information is contained in: (a) a paper presented to the 20th Annual ISA Conference and Exhibit, October 1965, "Development of Ablation Sensors for Advanced Reentry Vehicles," and (b) NASA TN D-3686 "Development of Sensors to Obtain In-Flight Ablation Measurements of Thermal Protection Materials."
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10592

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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